

the susceptor and the heating unit are accommodated in the processing chamber,

the substrate is processed in a state in which the susceptor is rotated relative to the heating unit,

at least the susceptor is lifted and lowered in the processing chamber,

a lifting and lowering apparatus is disposed in the processing chamber for lifting and lowering the substrate with respect to at least a portion of the susceptor, and

when the substrate is lifted or lowered, at least with respect to the portion of the susceptor, a distance between the susceptor and the heating unit is maintained constant.

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According to the above-described substrate processing apparatus, when the substrate to be processed is transferred to and from the susceptor, a space (vacant space) can be formed below the substrate to be processed by lifting and lowering the substrate to be processed by the substrate to be processed lifting and lowering apparatus. Therefore, a tweezer of a mechanical type substrate transfer apparatus can be inserted into the space. That is, by inserting the tweezer into the space below the substrate to be processed, the substrate to be processed can be mechanically supported by the tweezer from below and thus, the substrate to be processed can be transferred by the mechanical type substrate transfer apparatus. That is, it is unnecessary to use a vacuum absorption and holding apparatus or a static absorption and holding apparatus having a complicated structure for transferring the substrate to be processed.

According to a second aspect of the present invention, there is provided a substrate processing apparatus, including:

a susceptor disposed in a processing chamber and on which a substrate is placed, and

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a heating unit disposed below the susceptor in the processing chamber for heating the substrate placed on the susceptor, wherein

an upper surface of a peripheral portion of the susceptor and an upper surface of the substrate placed on the susceptor are flush with each other, and

when the substrate is lifted or lowered, at least with respect to a portion of the susceptor, a distance between the susceptor and the heating unit is maintained constant.

According to a third aspect of the present invention, there is provided a substrate processing apparatus, including:

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a susceptor on which a substrate is placed; and

a heating unit disposed below the susceptor for heating the substrate placed on the susceptor, wherein

when the substrate is lifted or lowered, at least with respect to a portion of the susceptor, a distance between the susceptor and the heating unit is maintained constant."

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Please replace the paragraph on page 9, lines 7-9, with the following text:

A2  
"A substrate processing apparatus according to one embodiment of the present invention will be explained with reference to the drawings below."

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Please replace the two paragraphs starting on page 11, line 20, and continuing to page 12, line 23, with the following text:

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"A heating unit 27 is concentrically disposed on an upper end of the support shaft 26 and horizontally fixed thereto, and the heating unit 27 is lifted and lowered by the support shaft 26. That is, the heating unit 27 is provided with a doughnut-like flat-plate shaped support plate 28, and an inner peripheral portion of the support plate 28 is fixed to an upper end opening of the support shaft 26. A plurality of electrodes 29 serving also as columns vertically stand on an upper

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surface of the support plate 28 at a plurality of inner peripheral locations and outer peripheral locations of the support plate 28. A heater 30 bridges over and is fixed between upper ends of the electrodes 29. The heater 30 entirely uniformly heats the wafer 1 held by a susceptor 40 (which will be described later).

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A reflection plate 31 on which a titanium thin film is mirror-finished is horizontally supported by columns 32 standing on the support plate 28 below the heater 30 of the heating unit 27. The reflection plate 31 effectively reflects heat waves radiated from the heater 30 vertically upward. A plurality of thermocouples 33 as temperature sensors are disposed on the support plate 28 at appropriate distances from each other such as to project above the heater 30. The thermocouples 33 measure a temperature of the wafer 1 heated by the heater 30. Electric wires (not shown) of the heater 30 and the thermocouples 33 are connected to an external power supply or a controller through an opening of the support plate 28 and a hollow portion of the support shaft 26 from the heating unit 27."

Please replace the two paragraphs starting on page 25, line 4, and continuing to page 26, line 10, with the following text:

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"(5) For the reason of the paragraph (4), it is unnecessary to employ the vacuum absorption type wafer transfer apparatus using the vacuum absorption and holding apparatus or the static absorption type wafer transfer apparatus using the static absorption and holding apparatus having a complicated structure as the wafer transfer apparatus. Therefore, it is possible to largely reduce the production cost of the single wafer-fed CVD apparatus. Further, the application range of the invention is not limited, and the invention can be applied to general substrate processing apparatuses such as normal CVD apparatuses, decompression CVD apparatuses, and plasma CVD apparatuses. Since a vacuum absorption and holding apparatus including a non-contact type vacuum absorption and holding apparatus holds a wafer by a pressure difference between upper and lower surfaces of the wafer, the vacuum absorption and holding apparatus can not be used in a

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decompression chamber. Further, as the static absorption and holding apparatus absorbs a wafer utilizing static electricity, the apparatus can not be used when there is a possibility of electrostatic destruction, and a diselectrifying apparatus or an antistatic apparatus is required, and a structure and management of the apparatus become complicated.

A4  
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(6) The wafer lifting and lowering apparatus 50 is disposed outside the rotation drum 35, the three engaging members 53 slightly engage the outer periphery of the wafer 1 to support the wafer 1 from below. Therefore, the effect exerted on heating of the heating unit 27 of the wafer lifting and lowering apparatus 50 can be suppressed and thus, the temperature distribution of the wafer 1 can be controlled entirely uniformly over the entire wafer 1 irrespective of existence of the wafer lifting and lowering apparatus 50."

Please replace the paragraph starting on page 27, line 20, and continuing to page 28, line 1, with the following text:

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"Although the abutting members 55 of the wafer lifting and lowering apparatus 50 abut against the step-like abutting portion 56 formed on the side wall of the lower cap 13 of the chamber 12, in the above embodiment, the abutting members 55 may abut against a bottom surface (upper surface of the bottom cap 15) of the processing chamber 11."

Please replace the two paragraphs starting on page 29, line 21, and continuing to page 30, line 22, with the following text:

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"Three guide holes 68 are formed in the support plate 28 of the heating unit 27 so as to be opposed to the fixed insertion holes 66, respectively. Pins (movable pins, hereinafter) 69 for pushing up the wafer from the susceptor are vertically slidably fitted into the guide holes 68. Each of the moveable pins 69 includes a large-diameter portion and a small-diameter portion and formed into a round rod shape, and a lower end of the large-diameter portion is formed with a flange 70.

The flange 70 is opposed to a bottom surface of a support hole 67 formed in an upper end of the fixed insertion hole 66. The small-diameter portion of the upper end of the movable pin 69 is formed with a push-up portion 71. The push-up portion 71 passes through the reflection plate 31, the heater 30 and the susceptor 40.

AB That is, at three locations respectively opposed to the three movable pins 69 at the reflection plate 31, the heater 30 and the susceptor 40, insertion holes 72, 73 and 74 are formed such that the push-up portions 71 can be inserted into the insertion holes 72, 73 and 74. As shown in Fig. 6, the three insertion holes 74 formed in the susceptor 40 are positioned at an outer peripheral portion of the central member 41 of the susceptor 40, and the three insertion holes 74 disposed in the circumferential direction are opposed to the three fixed pins 61. Therefore, the insertion holes 74 do not interfere with the tweezer 2 of the wafer transfer apparatus to be inserted into the wafer carry in-out port 16."

cont Please replace the paragraph starting on page 35, line 18, and continuing to page 36, line 3, with the following text:

A7 "Further, since the heating unit 27 is supported by the support shaft 26 and is not rotated, the temperature distribution of the wafer 1 which is heated by the heating unit 27 while being rotated by the rotation drum 35 is controlled uniformly in the circumferential direction. If the temperature of the wafer 1 is uniform over the entire surface, the film thickness distribution and the film quality distribution of the CVD film formed on the wafer 1 by the thermochemical reaction is controlled uniformly over the entire surface of the wafer 1."

Please replace the paragraph on page 41, lines 9-17, with the following text:

A8 "Lengths of the movable pins 69 are set equal so as to push up the rotation-side ring 81 vertically, and the lengths correspond to the pushing-up amount of the wafer from the susceptor. Lower ends of the movable pins 69 are opposed to the bottom surface of the processing chamber 11, i.e., the upper surface of the bottom

cap 15 such that the movable pins 69 can be brought into and out of contact with the bottom surface of the processing chamber 11, i.e., the upper surface of the bottom cap 15."

Please replace the three paragraphs starting on page 42, lines 5, and continuing to page 43, line 13, with the following text:

"Lengths of the heater-side pins 85 are set equal to each other so as to push up the heater-side ring 84 vertically, and lower ends of the heater-side pins 85 are opposed to an upper surface of the rotation-side ring 81 with an appropriate air gas interposed therebetween. That is, when the rotation drum 35 is rotated, the heater-side pins 85 do not interfere with the rotation-side ring 81.

In the present embodiment, a plurality of three push-up pins (push-up portions, hereinafter) 87 are vertically upwardly projecting from an upper surface of the heater-side ring 84 at equal distances from one another in the circumferential direction. Upper ends of the push-up portions 87 pass through the reflection plate 31, the heater 30 and the susceptor 40 and are opposed to a lower surface of the central member 41 of the susceptor 40. Lengths of the push-up portions 87 are set equal to each other such as to push up the central member 41 vertically. In a state in which the heater-side ring 84 sits on the support plate 28, an upper end of the heater-side ring 84 is opposed to an upper surface of the central member 41 with an appropriate air gap therebetween. That is, the push-up portions 87 do not interfere with the susceptor 40 when the rotation drum 35 rotates.

In Fig.13, for the sake of expediency of illustration, the upper ends of the push-up portions 87 are located on the upper side of the heater 30, but as shown with phantom line in Fig.15A, it is preferable that the upper ends of the push-up portions 87 are located below the heater 30 and the reflection plate 31 in view of the heating effect of the heating unit 27. That is, if the push-up portions 87 are projecting above the heater 30 and the reflection plate 31, there is an adverse possibility that hot wires of the heater 30 and the reflection plate 31 are shielded."

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Please replace the paragraph on page 44, lines 2-19, with the following text:

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"As shown in Fig.11, when the wafer 1 is transferred out, if the rotation drum 35 and the heating unit 27 are lowered to the lower limit position by the rotation shaft 34 and the support shaft 26, the lower ends of the rotation-side pins 82 of the wafer lifting and lowering apparatus 80 abut against the bottom surface of the processing chamber 11, i.e., the upper surface of the bottom cap 15. Therefore, the rotation-side ring 81 is lifted with respect to the rotation drum 35 and the heating unit 27. The lifted rotation-side ring 81 pushes up the heater-side pins 85, and thereby pushes up the heater-side ring 84. If the heater-side ring 84 is pushed up, the three push-up portions 87 standing on the heater-side ring 84 support the central member 41 of the susceptor 40 from below, and float up the central member 41 from the first peripheral member 42 and the second peripheral member 43. Since the central portion of the wafer 1 is placed on the central member 41, the wafer 1 is floated up."

Please replace the paragraph on page 45, lines 8-18, with the following text:

A11  
"As shown in Fig.2, the tweezer 2A inserted below the wafer 1 is lifted, and the tweezer 2A transfers and receives the wafer 1. At this time, the fork-like tweezer 2A receives an outer peripheral portion of the lower surface of the wafer 1. The tweezer 2 which received the wafer 1 moves the wafer backward through the carry in-out port 16 and transfers the wafer 1 out from the processing chamber 11. The wafer transfer apparatus which transferred out the wafer 1 by the tweezer 2A transfers the wafer 1 to a predetermined accommodating place (not shown) such as a vacant wafer cassette outside the processing chamber 11."

Please replace the paragraph starting on page 49, line 23, and continuing to page 50, line 9, with the following text:

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"When the exhaust amount of the exhaust port 18 and the rotation of the rotation drum 35 are established, the processing gas 3 is introduced into the gas introducing ports 21. The processing gas 3 introduced into the gas introducing ports 21 flows into the gas reservoir 24 by the exhausting force of the exhaust port 18 acting on the gas reservoir 24, and disperse radially outward, and flows from the blowout ports 23 of the plate 22 substantially uniformly, and blows out like a shower toward the wafer 1. The processing gas 3 blown out like a shower from the blowout ports 23 is drawn into the exhaust port 18 and exhausted."

Please replace the paragraph starting on page 50, line 23, and continuing to page 51, line 13, with the following text:

A12  
"Further, since the heating unit 27 is supported by the support shaft 26 and is not rotated, the temperature distribution of the wafer 1 which is heated by the heating unit 27 while being rotated by the rotation drum 35 is controlled uniformly in the circumferential direction. Since the susceptor 40 is not formed with the insertion holes through which the push-up portions 87 are inserted, and since the central member 41 is previously heated when receiving the susceptor 40, the temperature distribution of the wafer 1 is controlled uniformly over the entire wafer 1. If the temperature of the wafer 1 is uniform over the entire surface, the film thickness distribution and the film quality distribution of the CVD film formed on the wafer 1 by the thermochemical reaction is controlled uniformly over the entire surface of the wafer 1."

Please replace the three paragraphs starting on page 54, line 22, and continuing to page 56, line 14, with the following text:

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"As shown in Fig.16, when the wafer 1 is transferred in and out, the rotation drum 35 and the heating unit 27 are lowered to the transfer position of the



2. processing chamber 11 by the rotation shaft 34 and the support shaft 26, and the rotation drum 35 is lowered by the rotation shaft 34 with respect to the heating unit 27. If the rotation drum 35 is lowered with respect to the heating unit 27, the lifting and lowering ring 94 of the wafer lifting and lowering apparatus 90 is lifted with respect to the rotation drum 35. If the heating and lowering ring 94 is lifted with respect to the rotation drum 35, the three push-up portions 97 standing on the lifting and lowering ring 94 support the central member 41 of the susceptor 40 from below, and float up the central member 41 from the first peripheral member 42 and the second peripheral member 43. Since the central portion of the wafer 1 is placed on the central member 41, the wafer 1 is floated up.

A14  
Cont. As shown in Fig.16, when the wafer lifting and lowering apparatus 90 floats up the wafer 1 from the upper surface of the susceptor 40, the insertion space is formed below the wafer 1, i.e., between the lower surface of the wafer 1 and the upper surface of the susceptor 40. Next, a fork-like tweezer 2A of the wafer transfer apparatus is inserted into the insertion space of the wafer 1 from the wafer carry in-out port 16. That is, like the above-mentioned third embodiment, the wafer 1 can be transferred by the mechanical wafer transfer apparatus.

After the wafer 1 is transferred, as shown in Fig.17, the rotation drum 35 and the heating unit 27 are lifted by the rotation shaft 34 and the support shaft 26 with respect to the processing chamber 11, and the rotation drum 35 is lifted by the rotation shaft 34 with respect to the heating unit 27. If the rotation drum 35 is lifted with respect to the heating unit 27, the central member 41 supported by the push-up portion 97 of the lifting and lowering ring 94 is lowered with respect to the rotation drum 35, and the central member 41 is fit into the first peripheral member 42. In this state, the wafer 1 is moved onto the susceptor 40, and the upper surface of the wafer 1, the upper surface of the first peripheral member 42 and the upper surface of the second peripheral member 43 are flush with each other."